Experimental Studies of Flow Separation and Stalling on Two-Dimensional Airfoils at Low Speeds

Phase II: Studies with Fowler Flap Extended
NGR 17-003-021. Supplement 1.

Semi Annual Progress Report
June 1, 1975 - Nov. 30, 1975

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by

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(NASA-CR-145741) EXPERIMENTAL STUDIES OF FLOW SEPARATION AND STALLING ON TWO-DIMENSIONAL AIRFOILS AT LOW SPEEDS. PHASE 2: STUDIES WITH FOWLER FLAP EXTENDED Semiannual Progress Report, 1 Jun. - 30 Nov. G3/02

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Experimental Studies of Flow Separation and Stalling on Two-Dimensional Airfoils at Low Speeds

Phase II: Studies with Fowler Flap Extended (An Extension of Research Under NGR-17-003-021)

Semi Annual Report for the period: June 1, 1975 to Nov. 30, 1975

Experiments with Flaps 40°:

1. Five tube probe survey with optimum flap gap and overlap setting: About sixteen hours of tunnel work were completed as part of the repeat runs to confirm some "unusual" velocity distribution recorded within .25" from flap surface between midchord and flap trailing edge station at 12.5° angle of attack. Additional wake profiles at 7.5%c station on the flap and 30%c station downstream of the flap trailing edge were also obtained at angles of attack of 2.5°, 7.5° and 12.5°. Experimental velocity profiles are shown in figs. 1, 2 and 3.
2. Hot wire anemometer survey: $\alpha = 12.5^{\circ}$.
   In order to obtain preliminary qualitative information regarding the character of post-separated turbulent eddy, and the quantitative information regarding their frequency, hot wire anemometry was employed. Figure 4 indicates the typical zones of steady flow, intermittent turbulence and large scale turbulence. This figure illustrates the basic character of the turbulent flow field, qualitatively, as well as quantitative information regarding the frequency. These traces were obtained employing the Flow Corporation hot wire and the associated instrumentation, and are shown in the A.C. mode.

   A limited set of data obtained by employing the hot film probe and the associated instrumentation supplied by Thermal Systems, Inc., is shown in figs. 5 and 6. The operation is in D.C. mode and the flow survey was carried out at mid flap and 13%c station downstream of flap trailing edge.

3. Local Skin Friction Distributions: Razor blade method:

Basic Airfoil: A comparison of the theoretical result obtained from Lockheed program with the experimental result is shown for the case of $\alpha = 0^{\circ}$. (fig. 7). This technique was very successful up to the point of separation. (fig. 7a) Results were inconsistent downstream of the separation point.

Flaps 40°: About 15 repeat runs were made in order to confirm the consistency of the data. The results indicate the limitations of the the use of this method under partially separated conditions. At low angles of ataack (0°, 2.5°, and 7.5°), skin friction measurements could not be obtained in view of premature separation indicated on the flap. The situation however improves at 10° and 12.5° angles of attack on the flap. (fig. 8).

4. Boundary layer mouse data:

Computer plots of the boundary layer profiles are shown in fig. 9 for the case of flap 40° with optimum setting. Results of the slot flow velocity profile for wide and narrow gap settings are shown in figs. 10 and 11, along with the five tube probe data.

5. Static pressure contours: flaps 40°

Static pressure field contours are shown in figs. 12, 13, and 14. ($\alpha = 2.5^{\circ}$, 7.5°, and 12.5°).

6. Progress under the Expansion of the Grant: A GA(W)-2 section model was fabricated with 30%c Fowler flaps (under NSG 1165) and with pressure taps. As part of the above grant and complementary to NGR-17-003-021, extensive pressure, force and flow visualization data have been obtained. A NACA 2412 section model with 2' chord and 3' span has been obtained on loan from Cessna Pawnee Division. Boundary layer and flow field surveys of the above models

will be made during Feb.-Mar. 1976. Purchase requisition for the procurement of hot wire/hot film, and associated instrumentation has been initiated and this new equipment will be available during Feb. 1976 testing.

7. Participation in Seminars:

a) J. K. WALKER: Received Third prize in the Region V of AIAA Student Paper Competition held in 22-25 April 1975, for the paper, "Calibration of a Five-Tube Probe".

b) Dr. H. C. SEETHARAM: Presented a paper, "Measurements of Flow Fields on Airfoils", at the AIAA First General Aviation Technologyf Nov. 13-14, 1975. Title page of AIAA paper 75-1426 is enclosed.

c) Dr. W. H. WENTZ, JR.: Participated in the Airfoil Workshop conducted under the auspices of NASA and the chairmanship of Mr. Kenneth Pierpont. Flow field patterns for flaps 40° were shown as part of his oral presentation.

8. Present Status:

Most of the figures for inclusion in the report on the 2-element airfoil separated flow studies are ready. In view of the extensive analyses being done and the need for additional hot film data, the projected date for submission of the complete report for review by NASA personnel is now March 1, 1976.

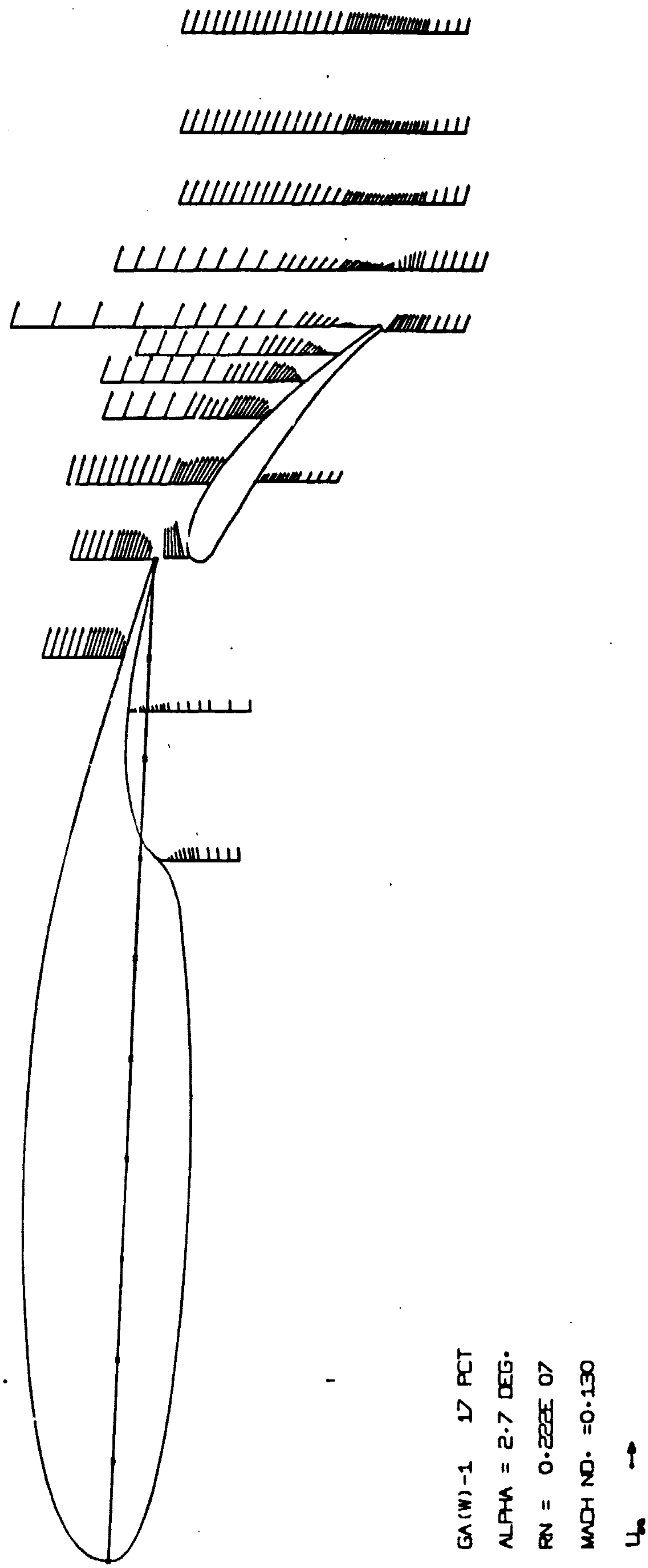

Figure 1

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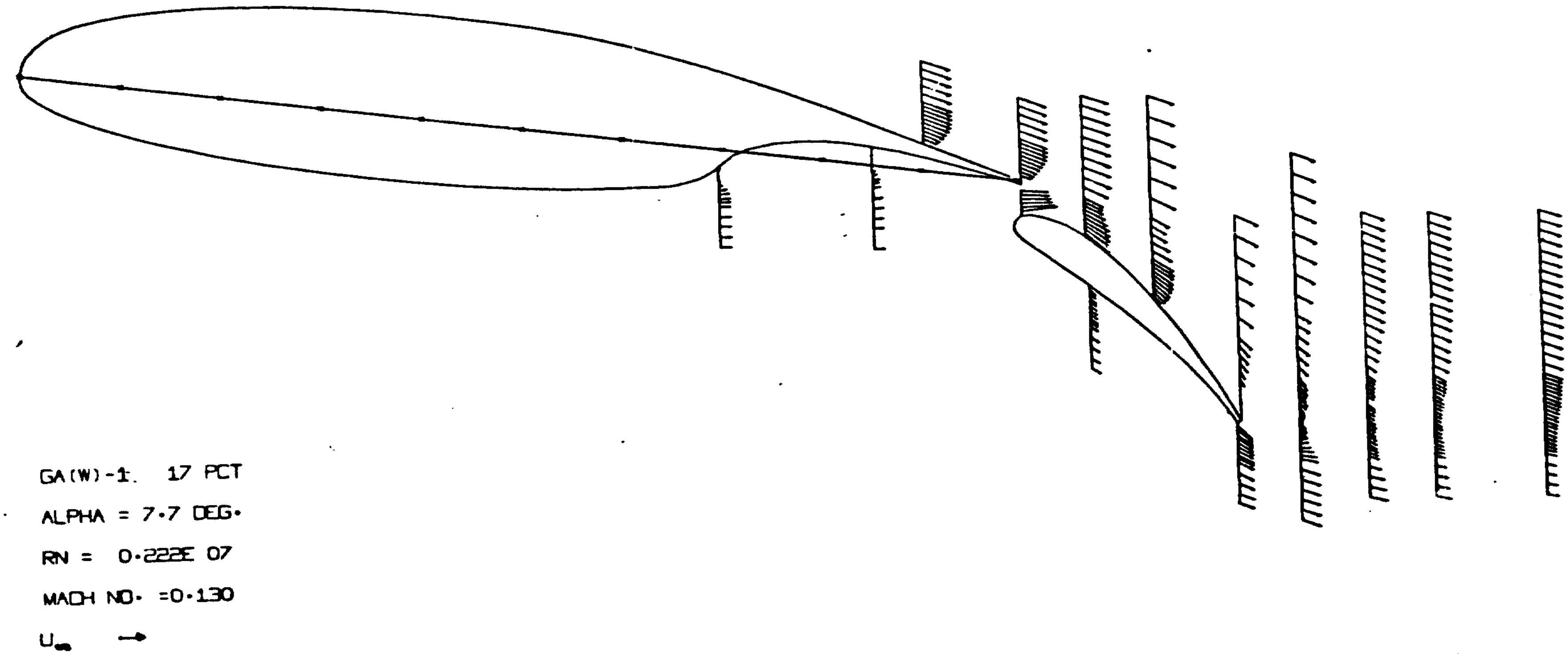


Figure 2

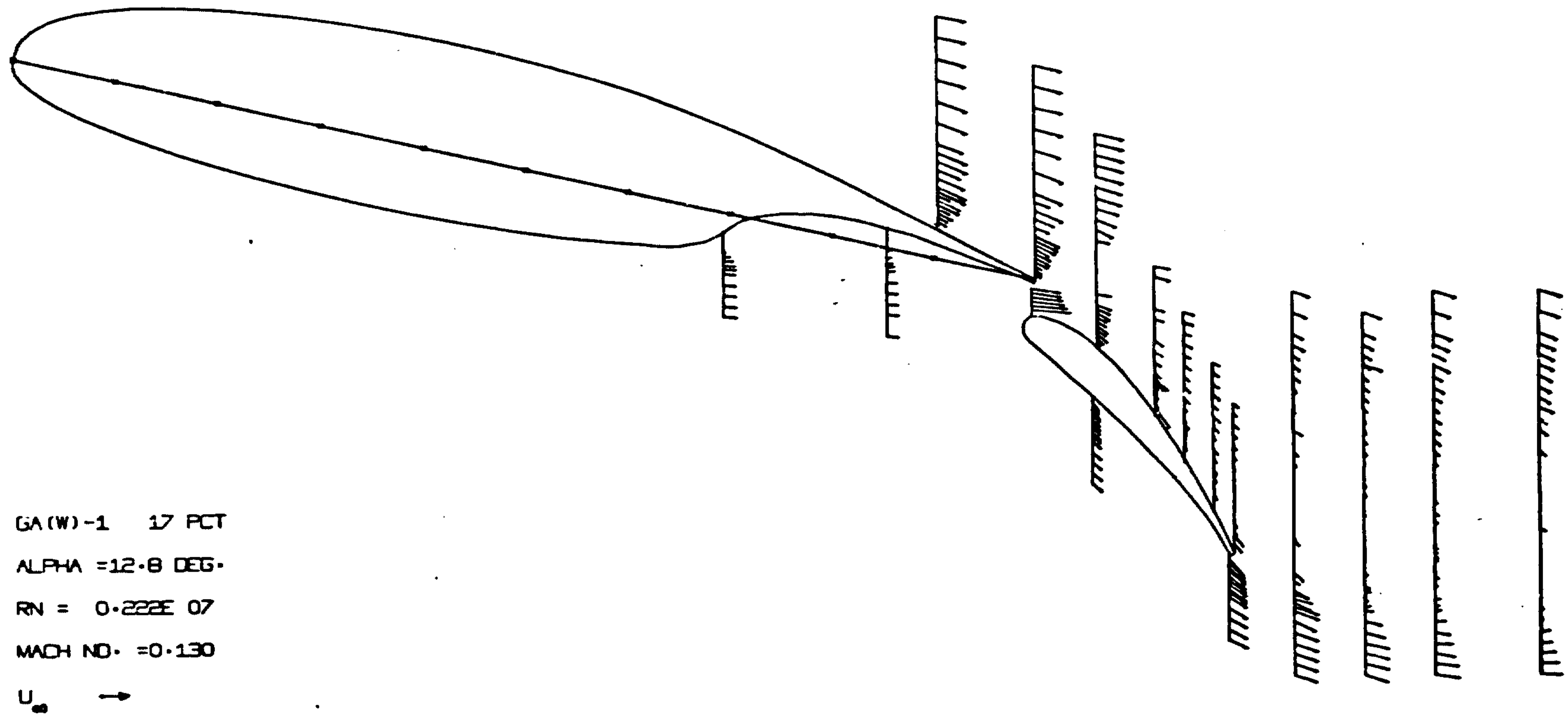
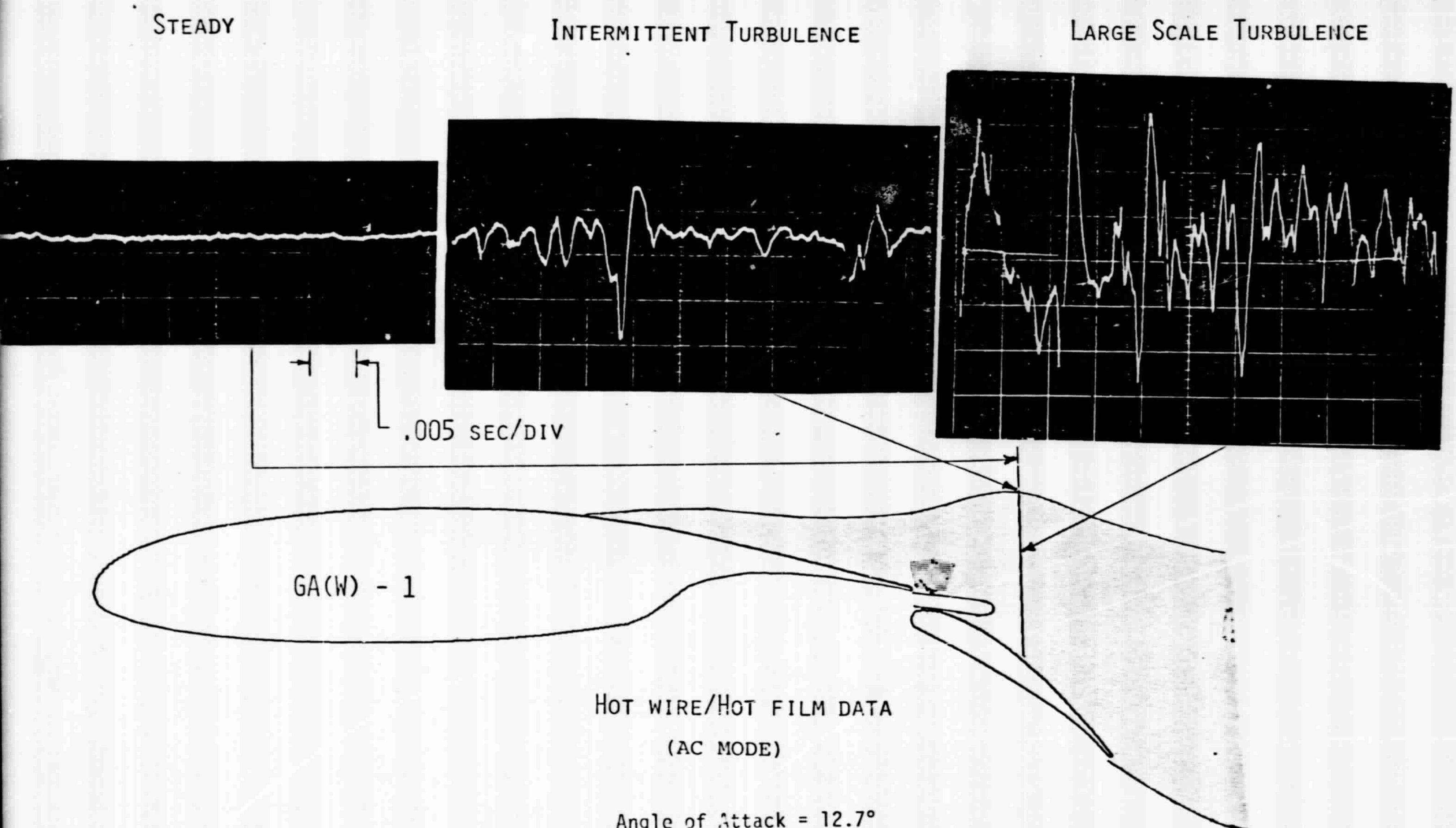
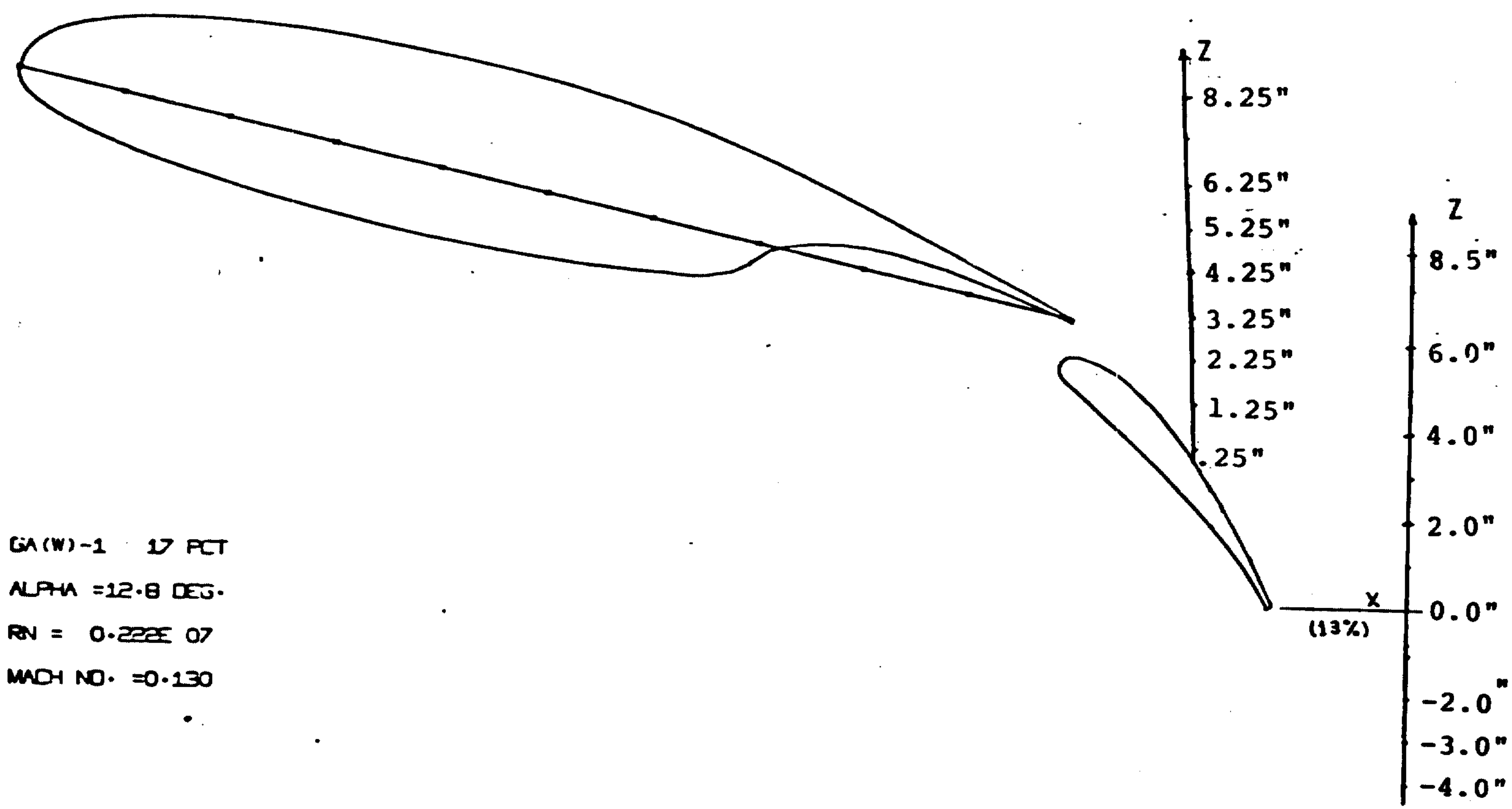


Figure 3



MULTI-ELEMENT - SEPARATED FLOW MEASUREMENTS

Figure 4



(HOT-WIRE/HOT-FILM SURVEY LOCATIONS
FOR FIGURES 5 AND 6)

TSI Hot Film Anemometer Survey

Flap = 40° Angle of attack = 12.5° GA (W)- 1 Airfoil
Survey Station: 13% Down stream of Flap Trailing Edge

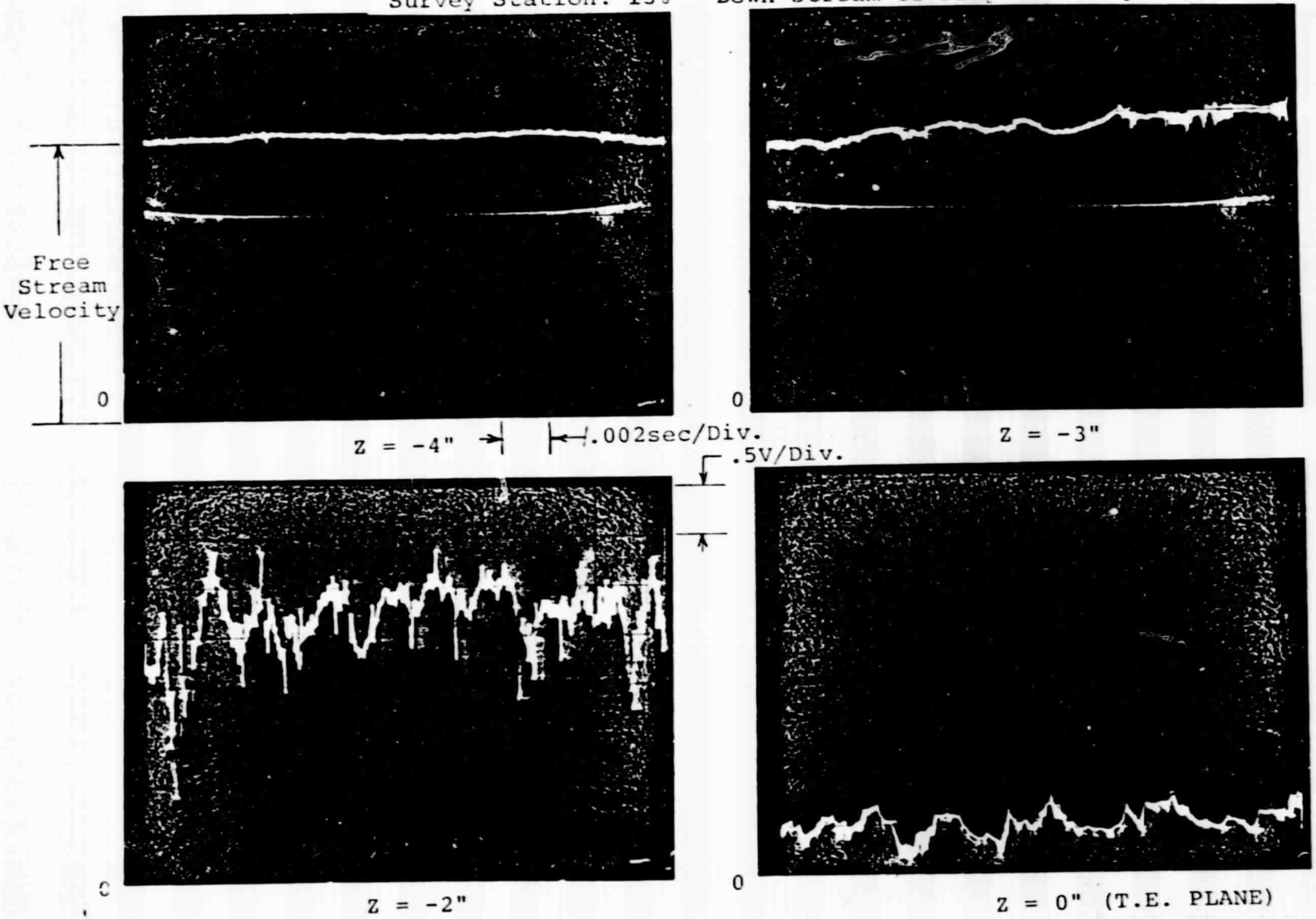


Figure 5

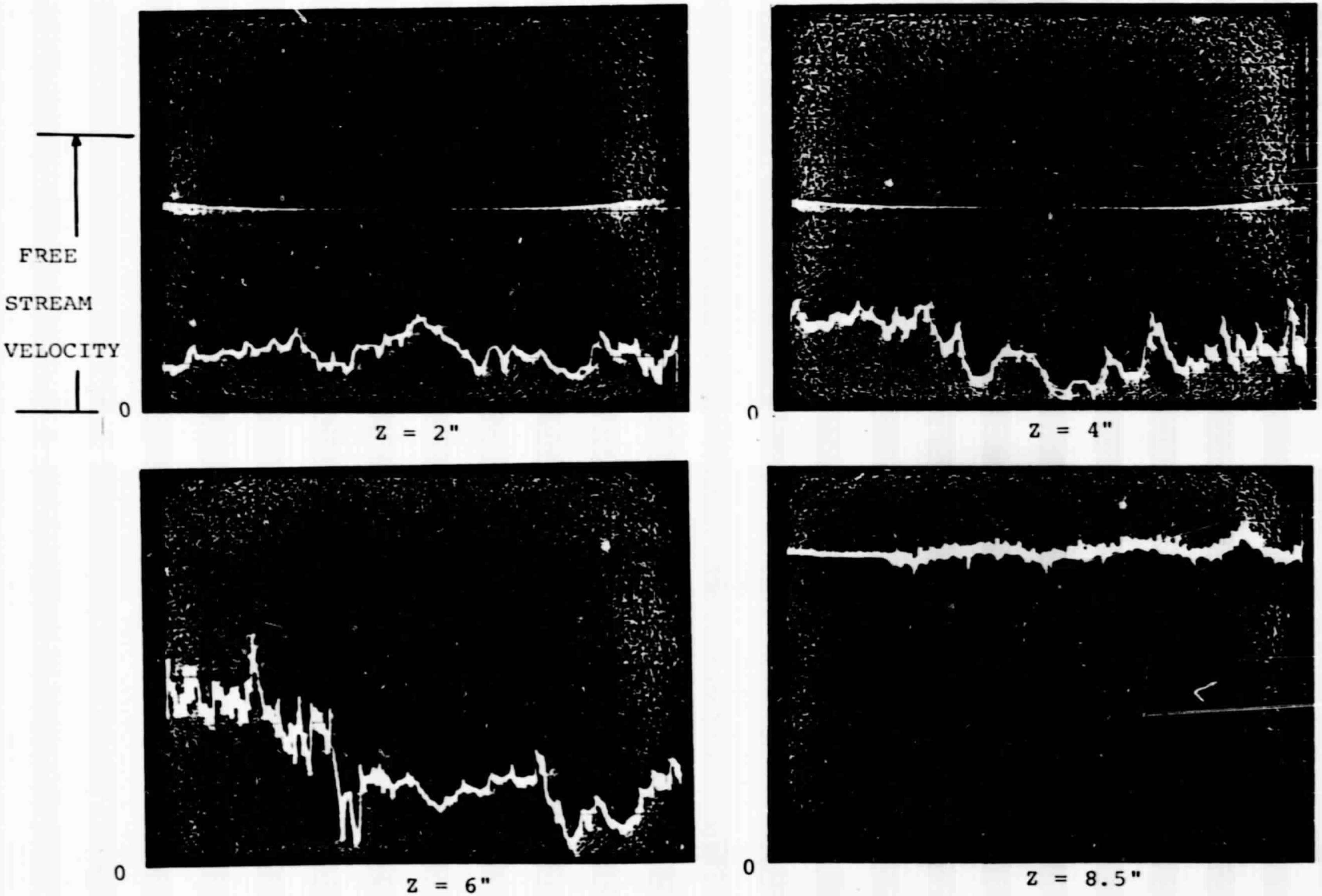


Figure 5 CONCLUDED

Survey Station: Mid-Flap-Chord Location

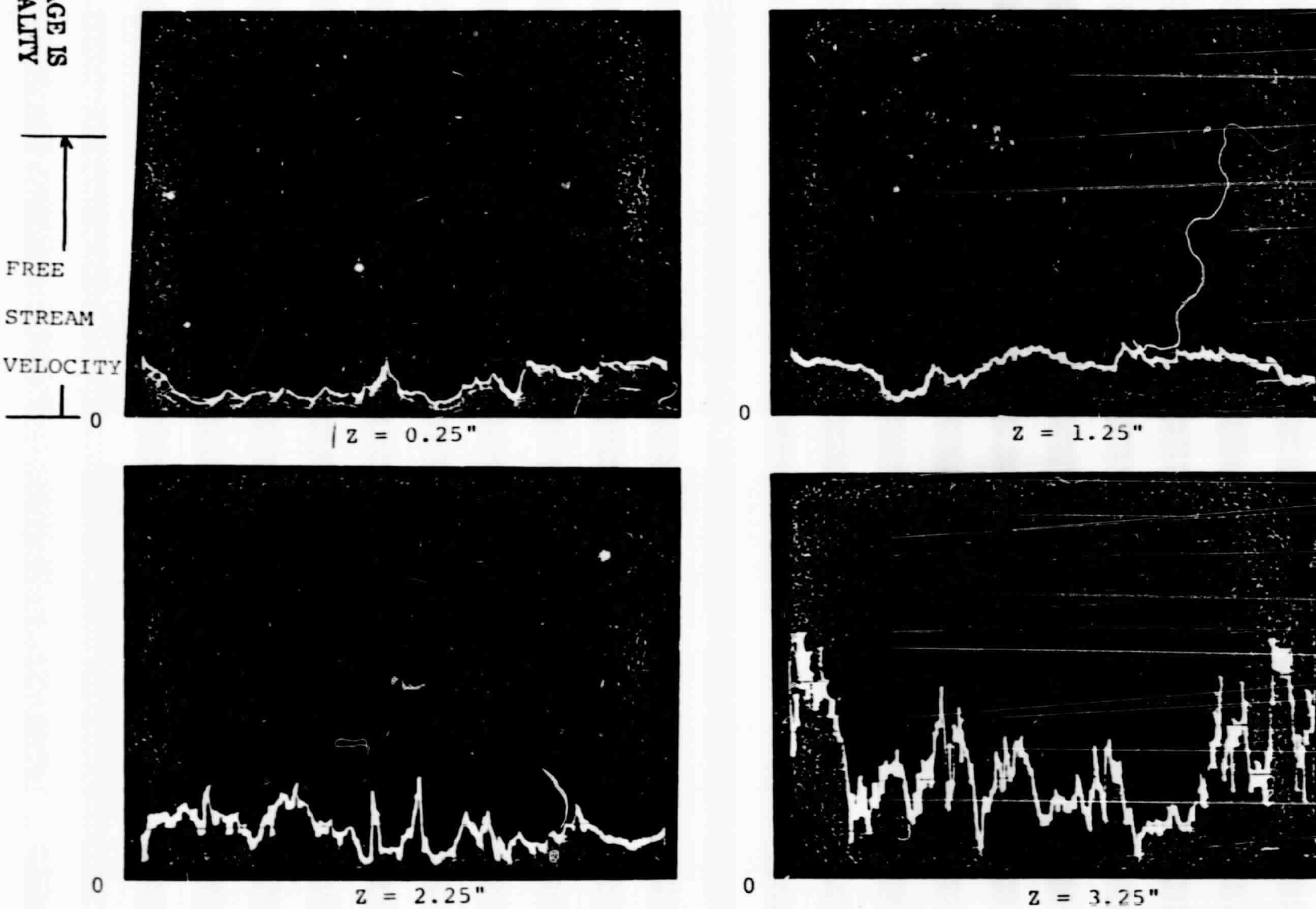


Figure 6

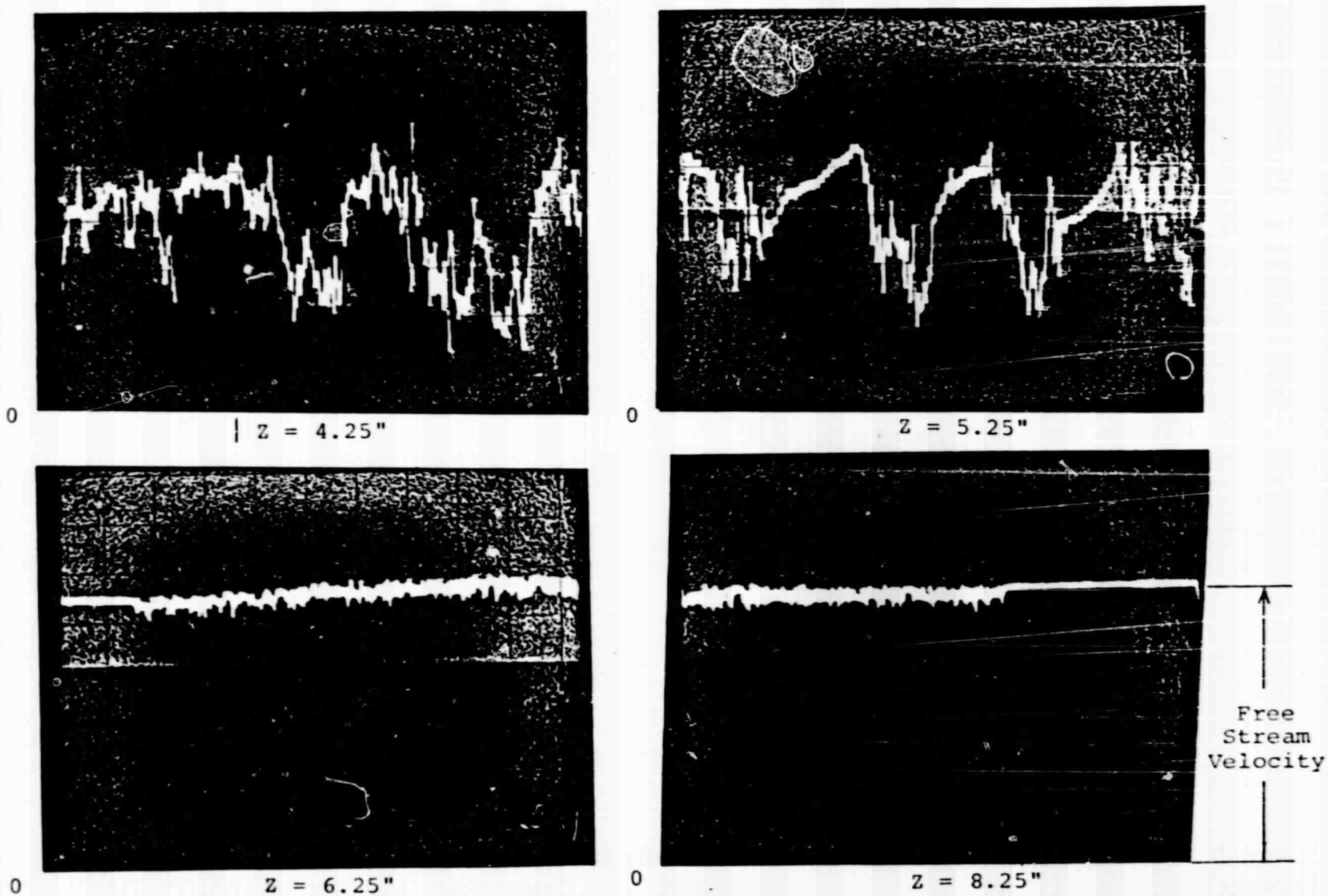


Figure 6 CONCLUDED

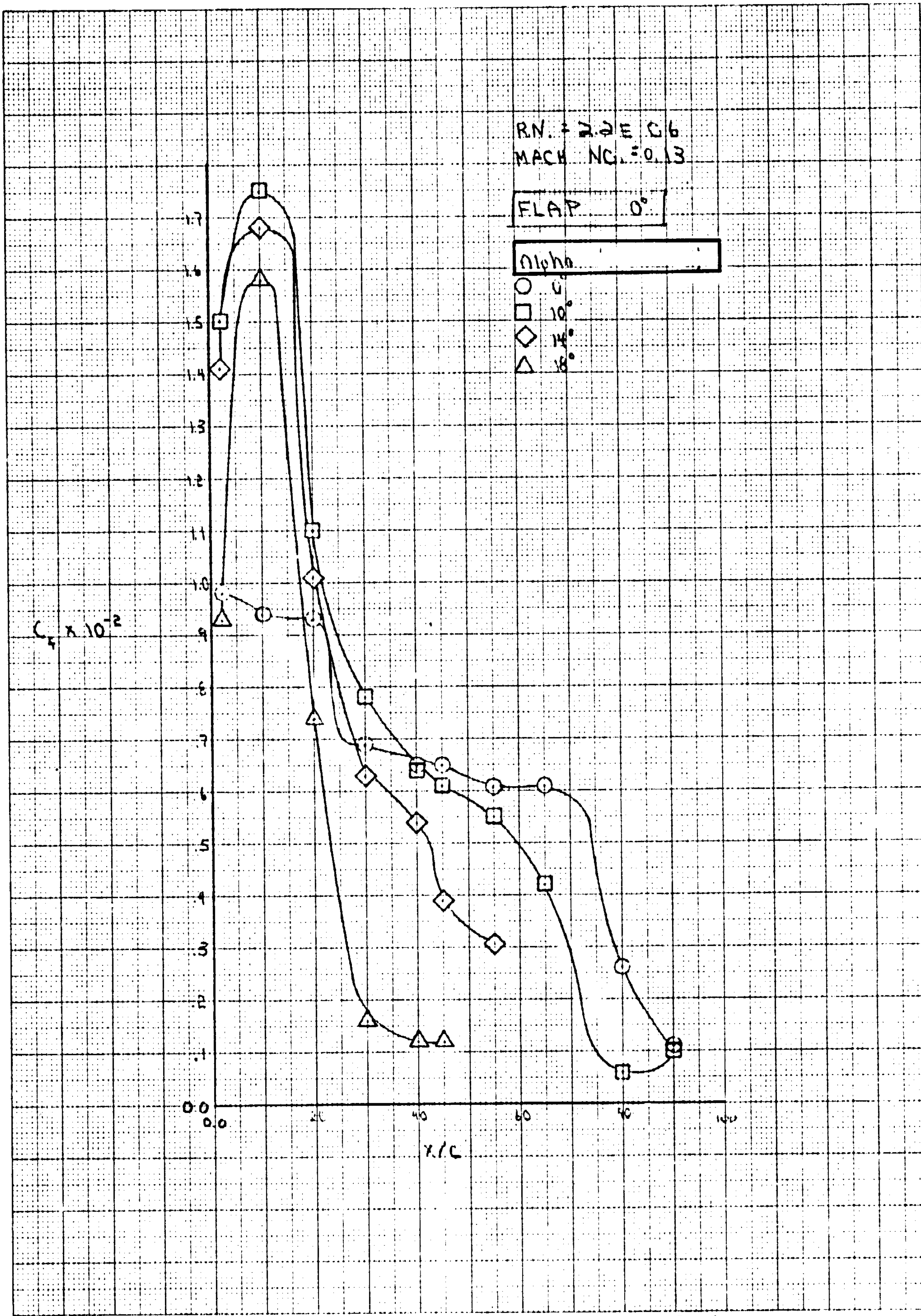


FIGURE - 7A

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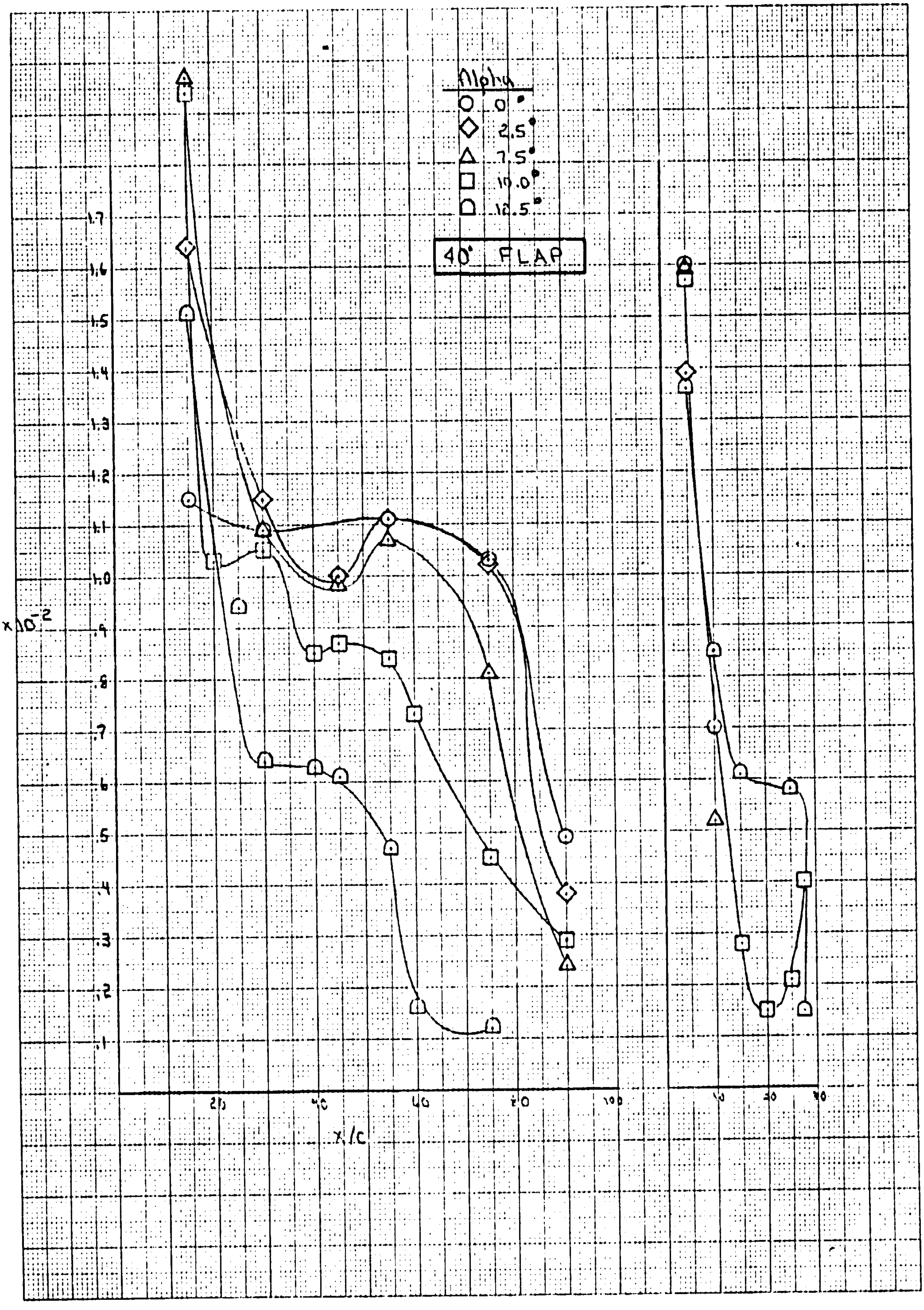
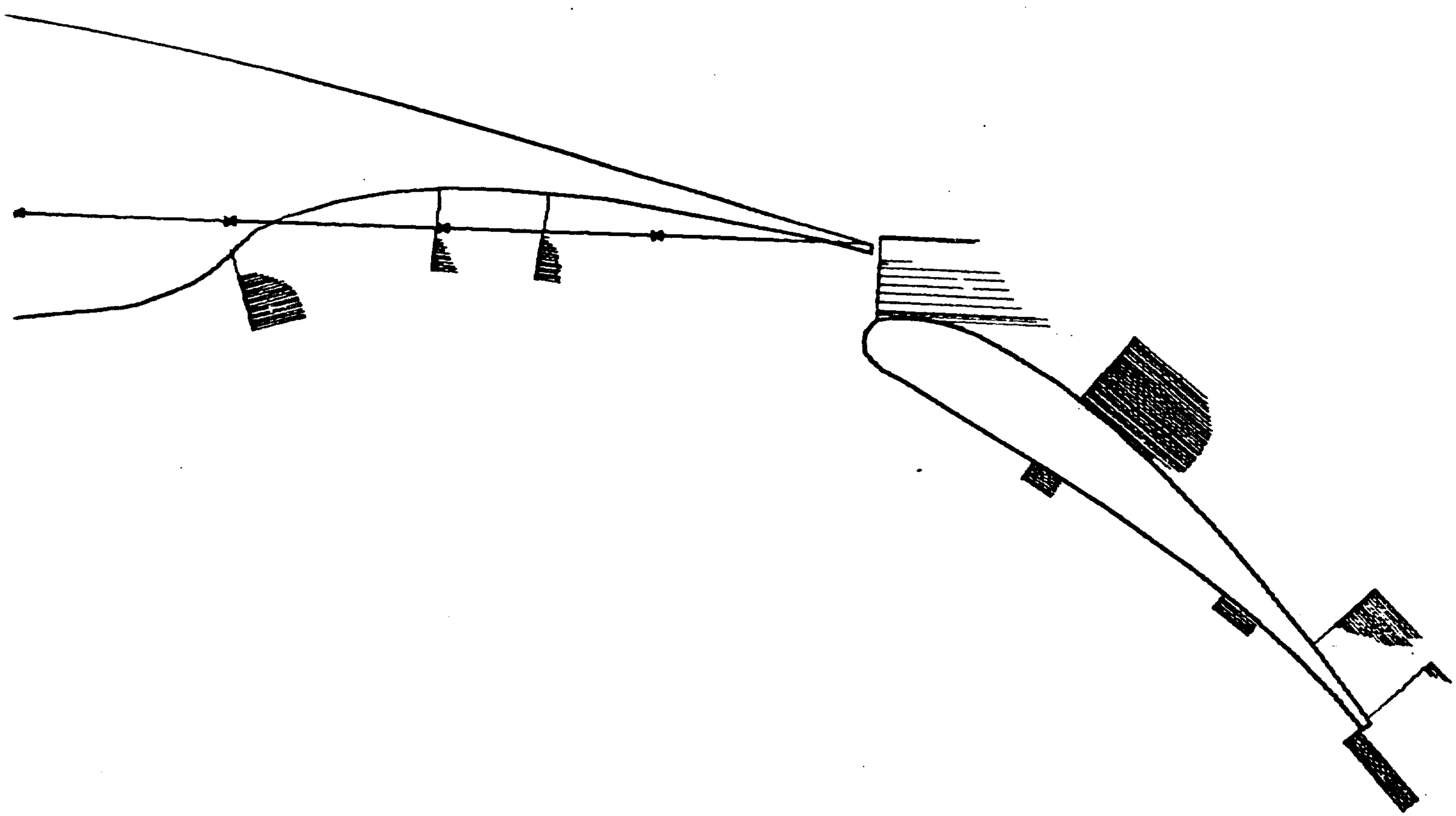
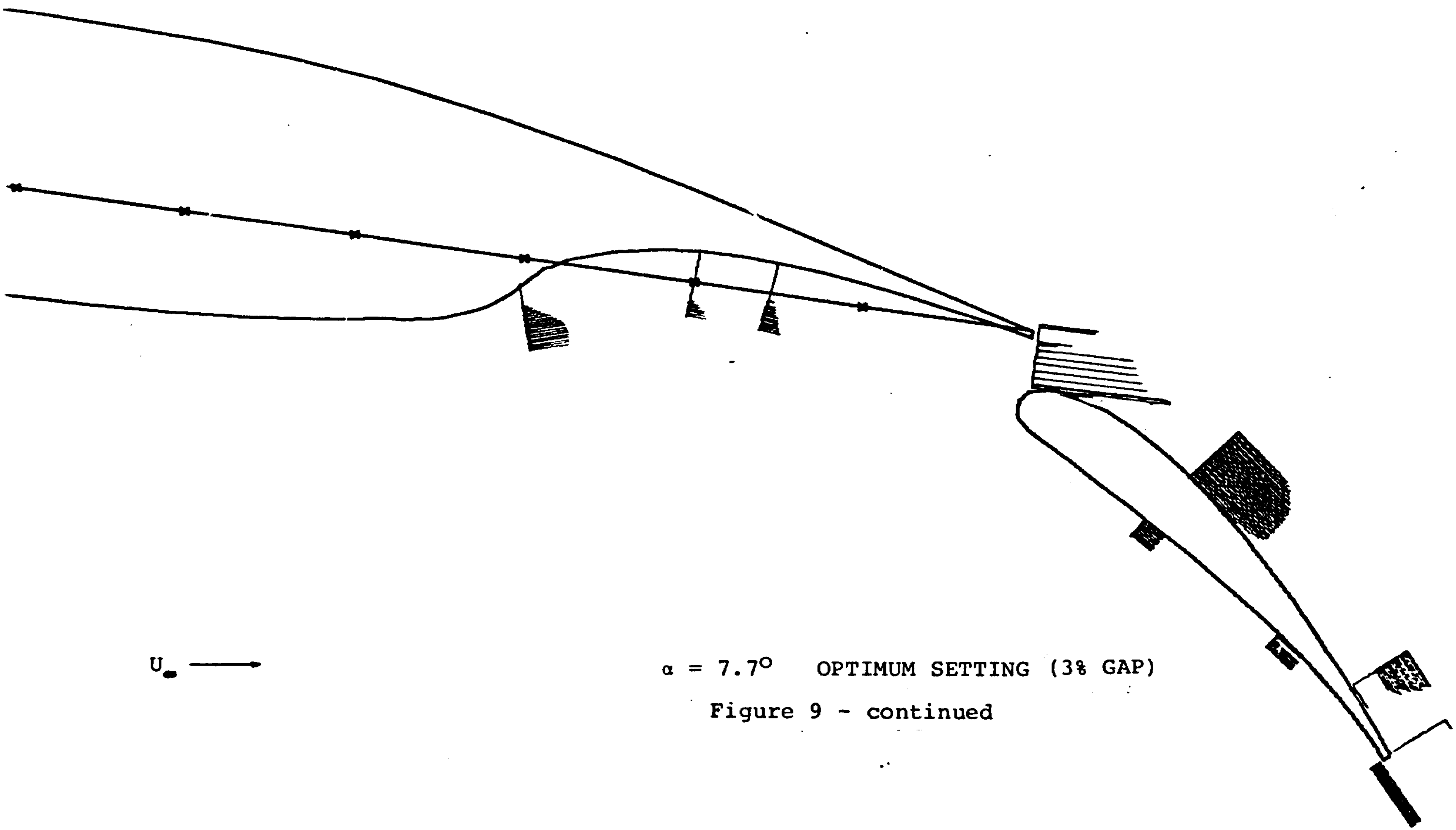


Figure 8



$\alpha = 2.7^{\circ}$ OPTIMUM SETTING (3 % GAP)

Figure 9



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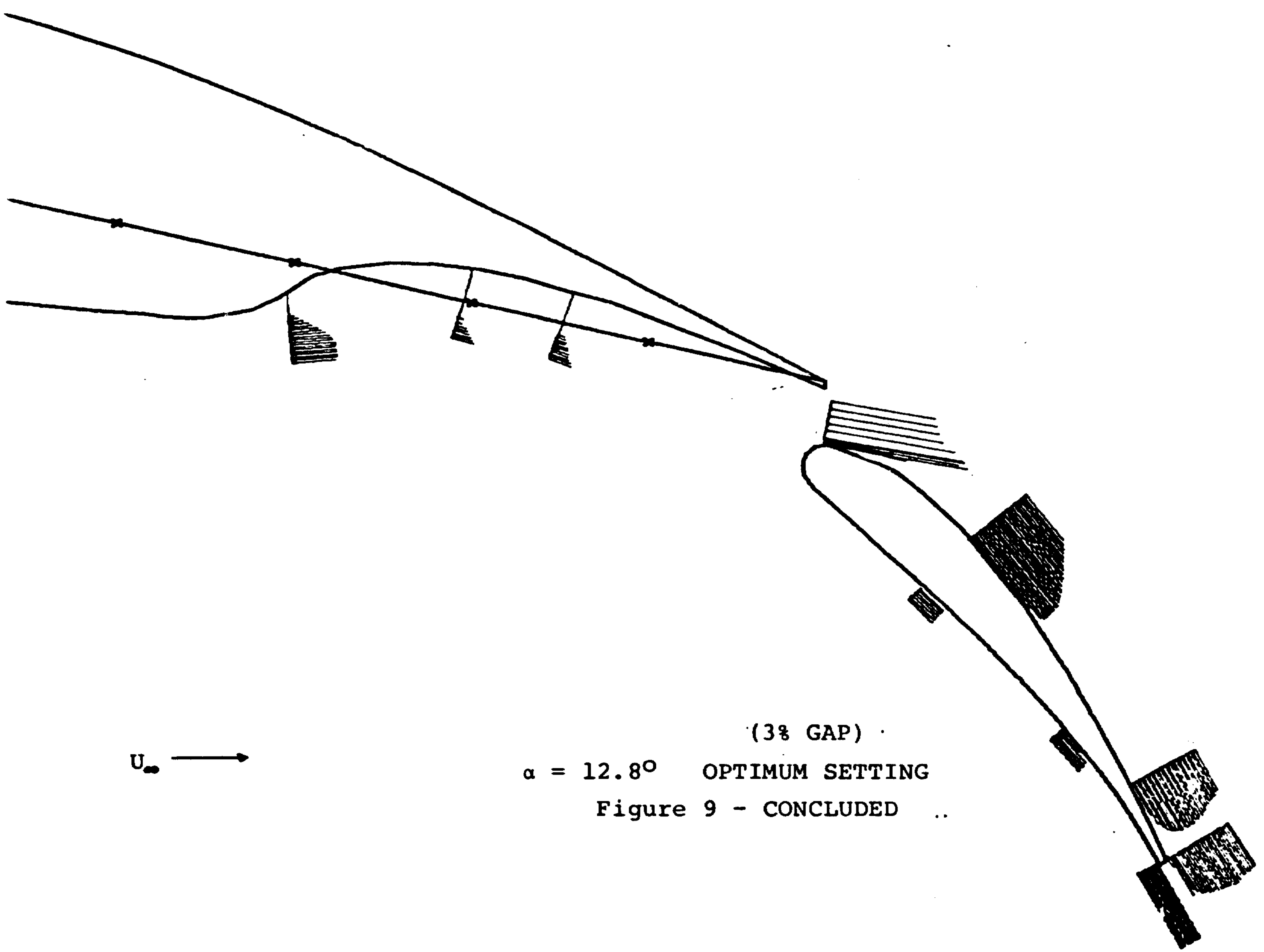
$\alpha = 7.7^\circ$ OPTIMUM SETTING (3% GAP)

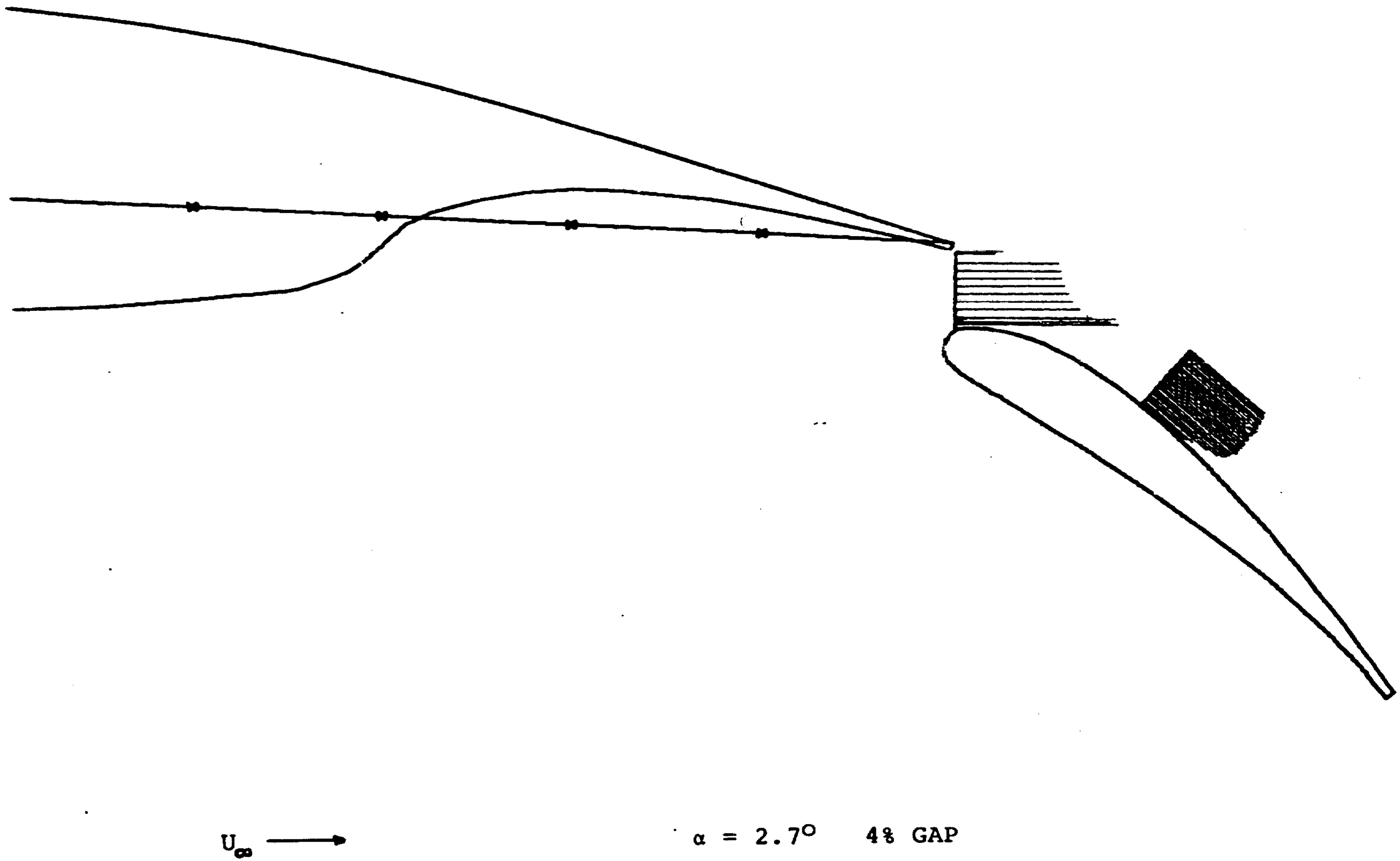
Figure 9 - continued



(3% GAP)

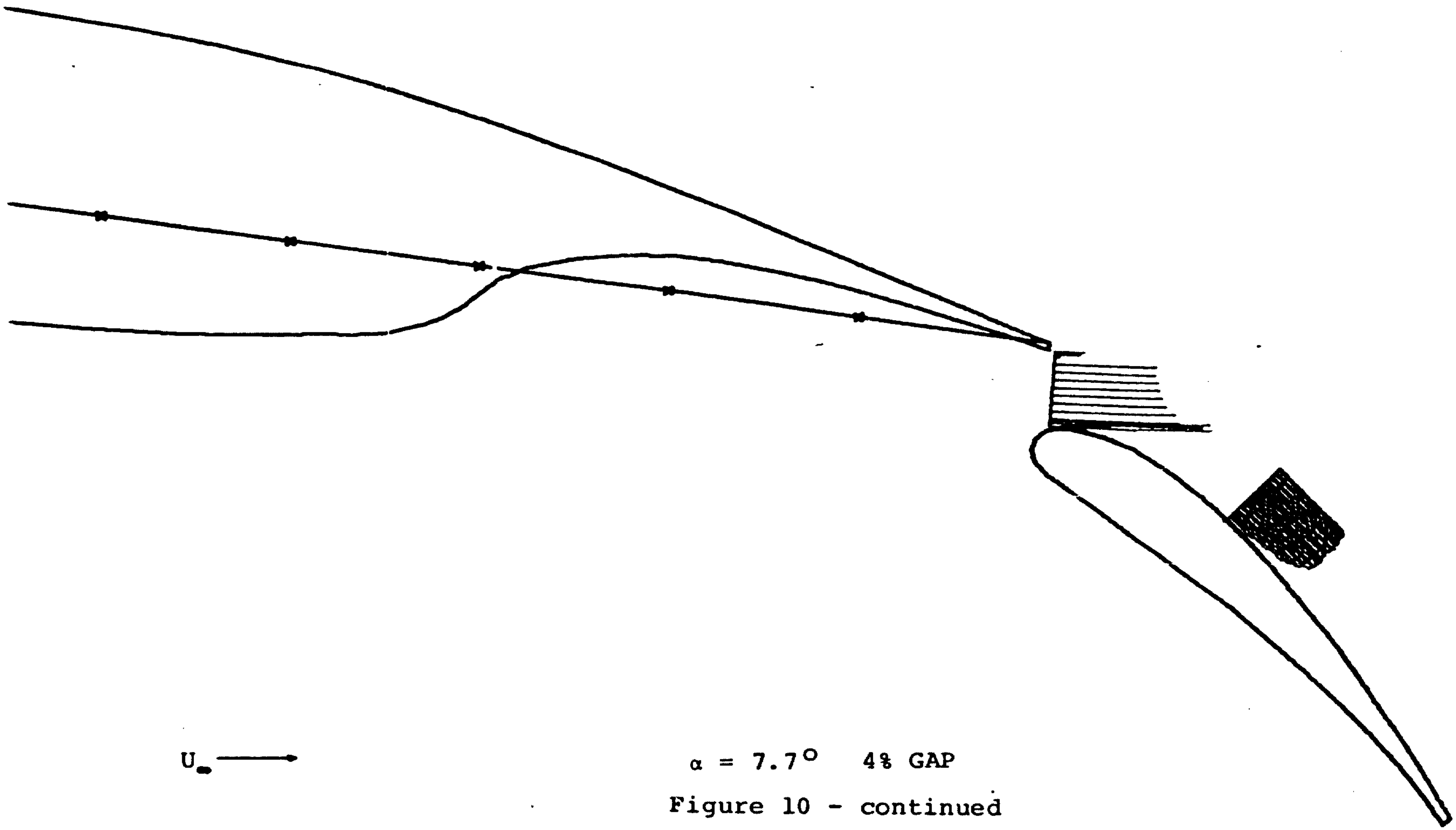
$\alpha = 12.8^{\circ}$ OPTIMUM SETTING

Figure 9 - CONCLUDED



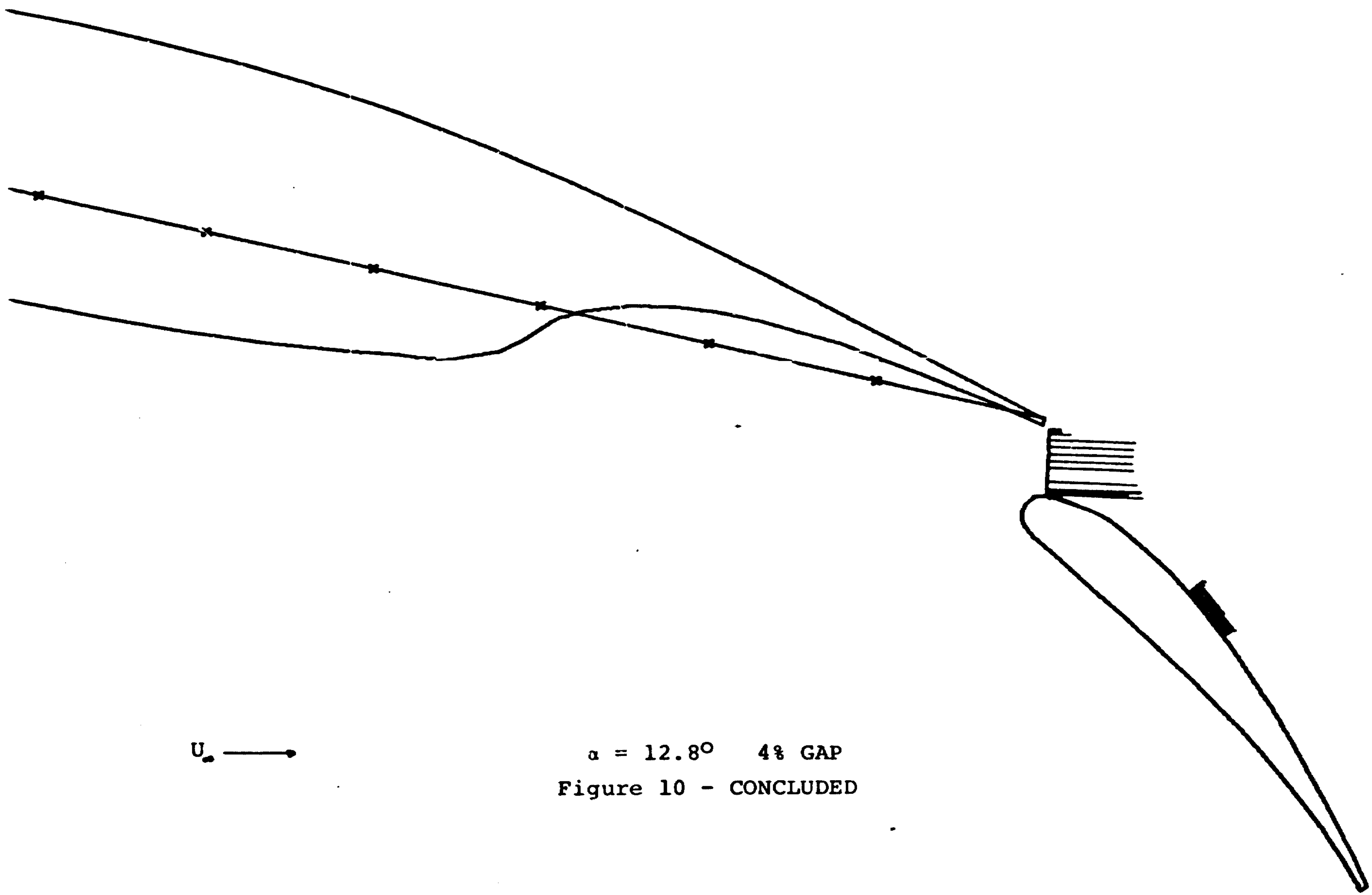
$\alpha = 2.7^{\circ}$ 4% GAP

Figure 10



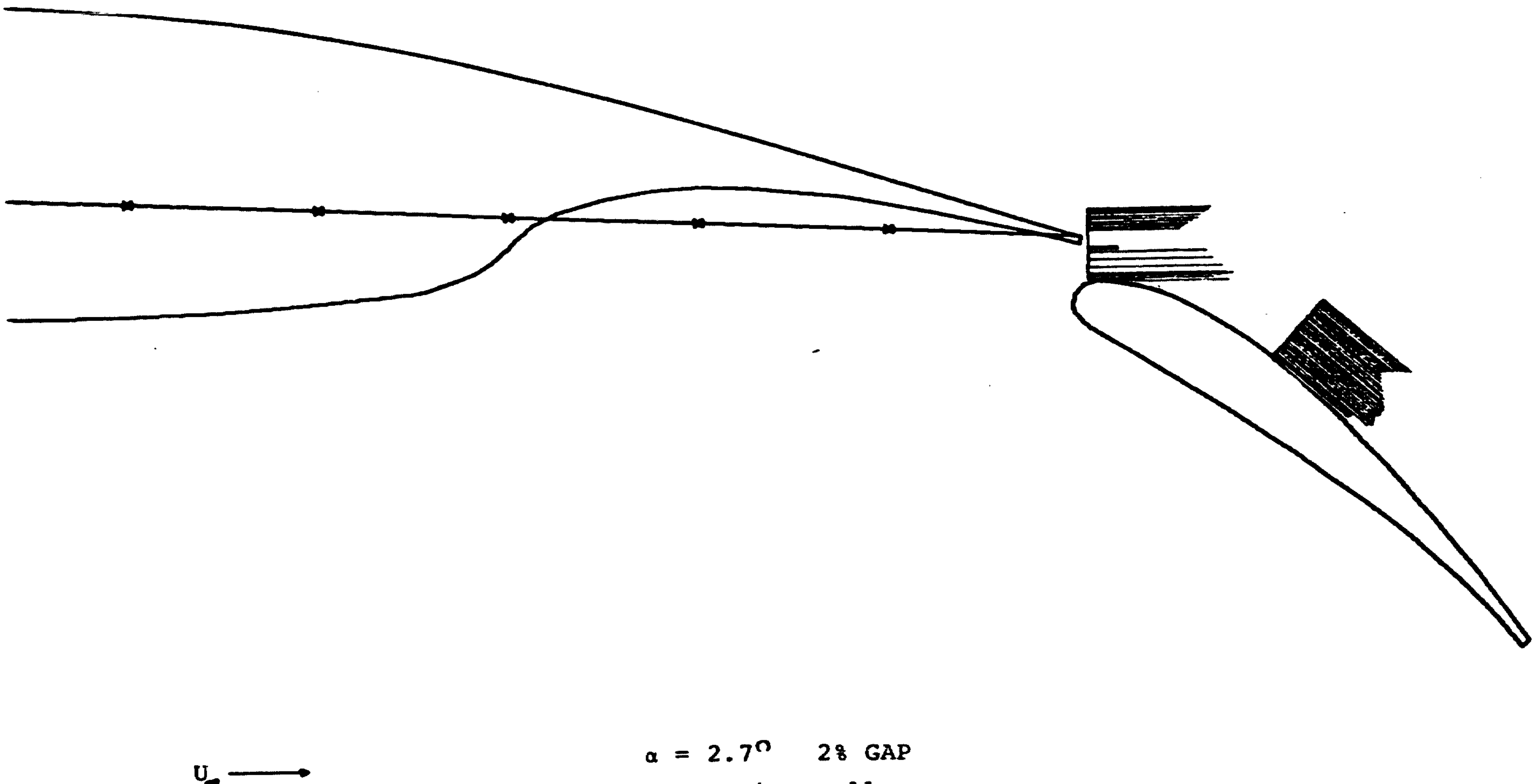
$\alpha = 7.7^{\circ}$ 4% GAP

Figure 10 - continued



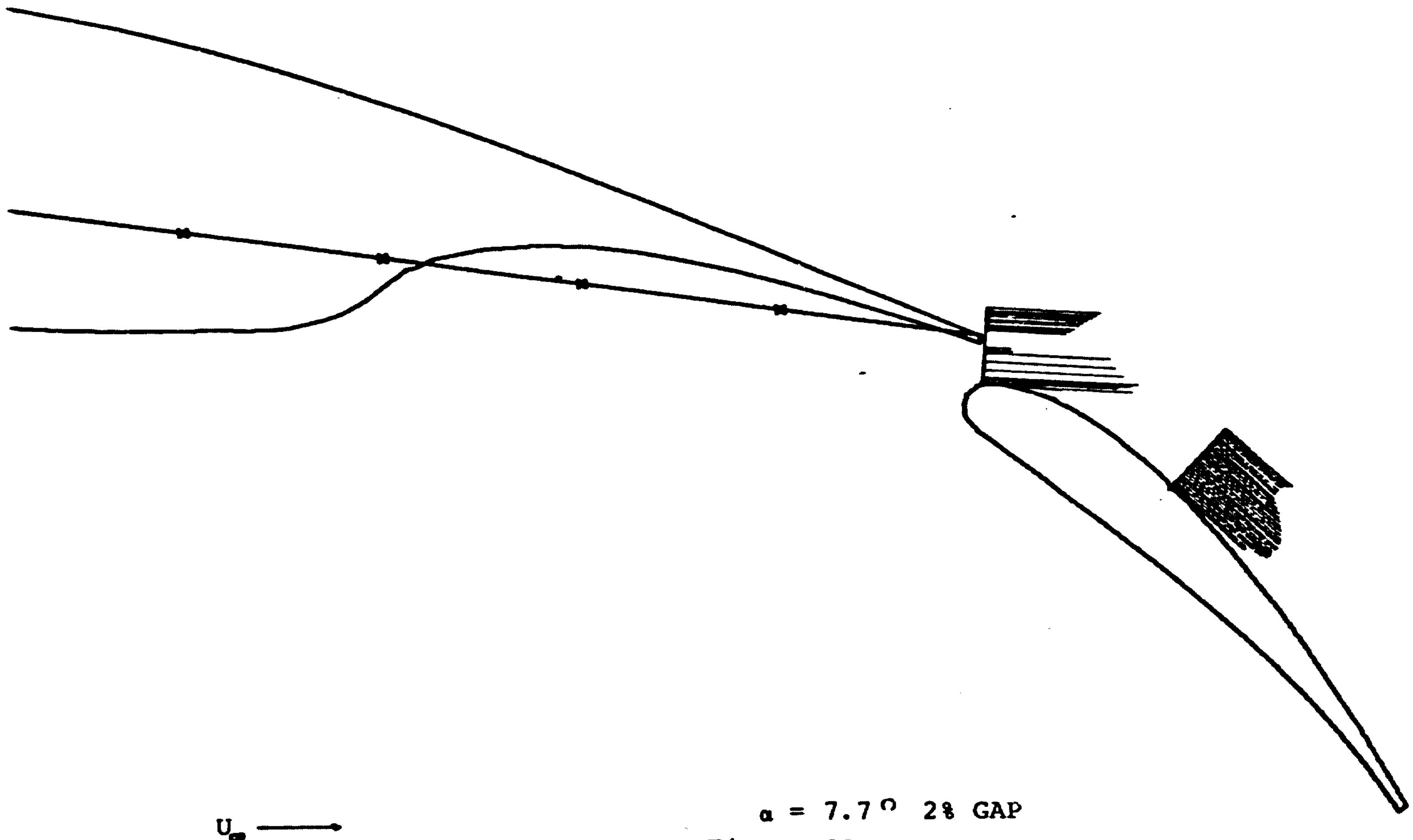
$\alpha = 12.8^{\circ}$ 4% GAP

Figure 10 - CONCLUDED

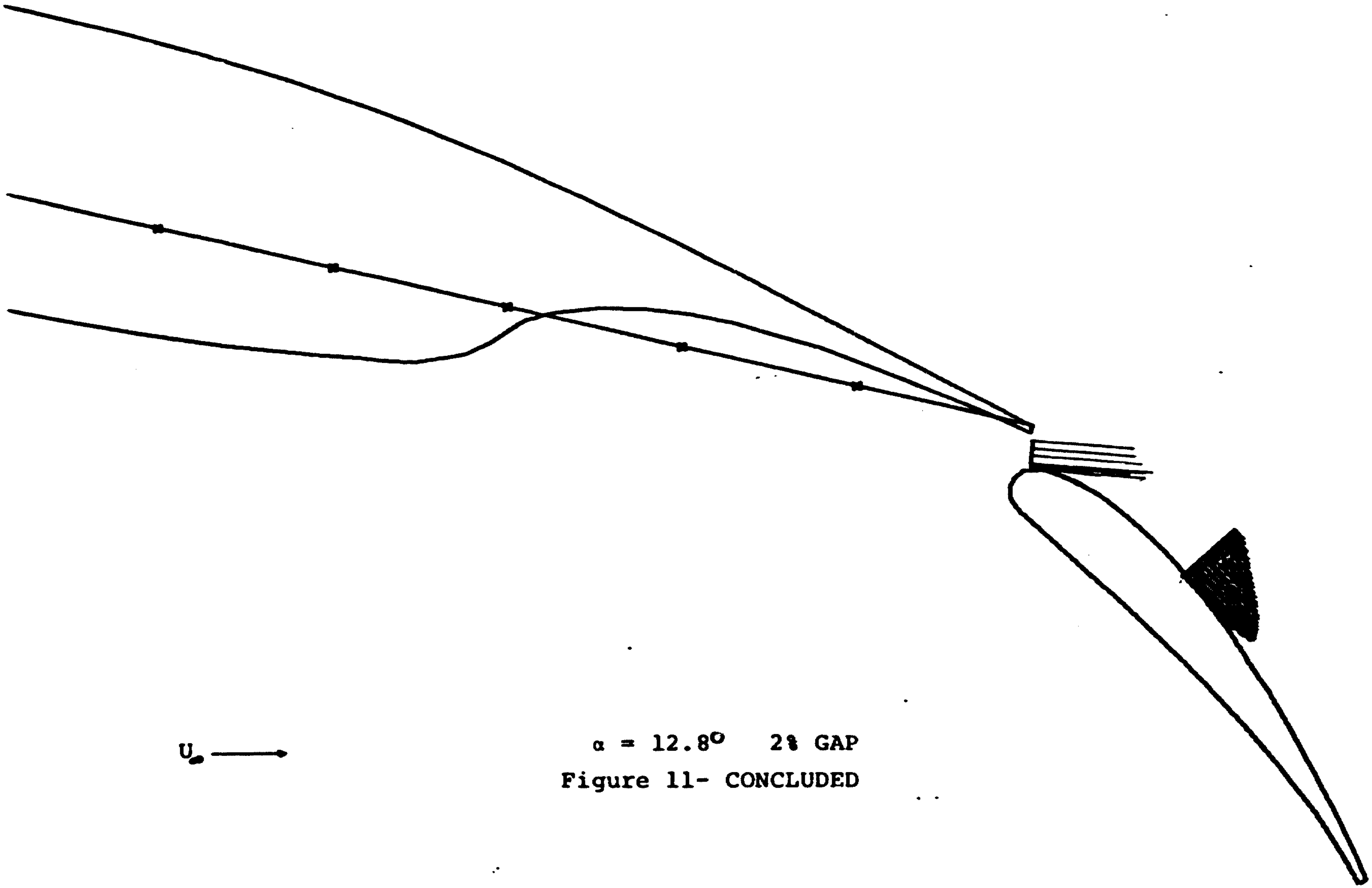


$\alpha = 2.7^{\circ}$ 2% GAP

Figure 11

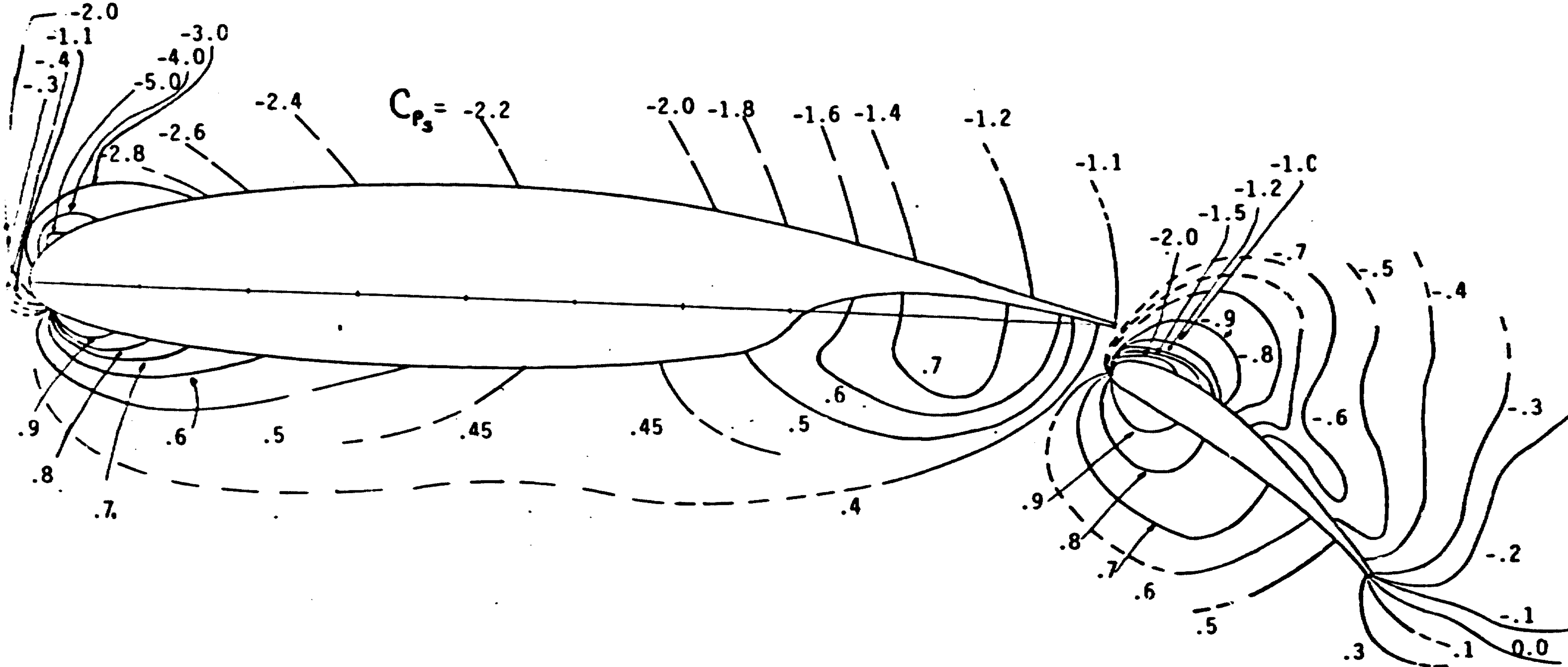


$\alpha = 7.7^{\circ}$ 2% GAP
Figure 11 - continued



$\alpha = 12.8^{\circ}$ 2% GAP

Figure 11- CONCLUDED



GA(W)-1   17 PCT

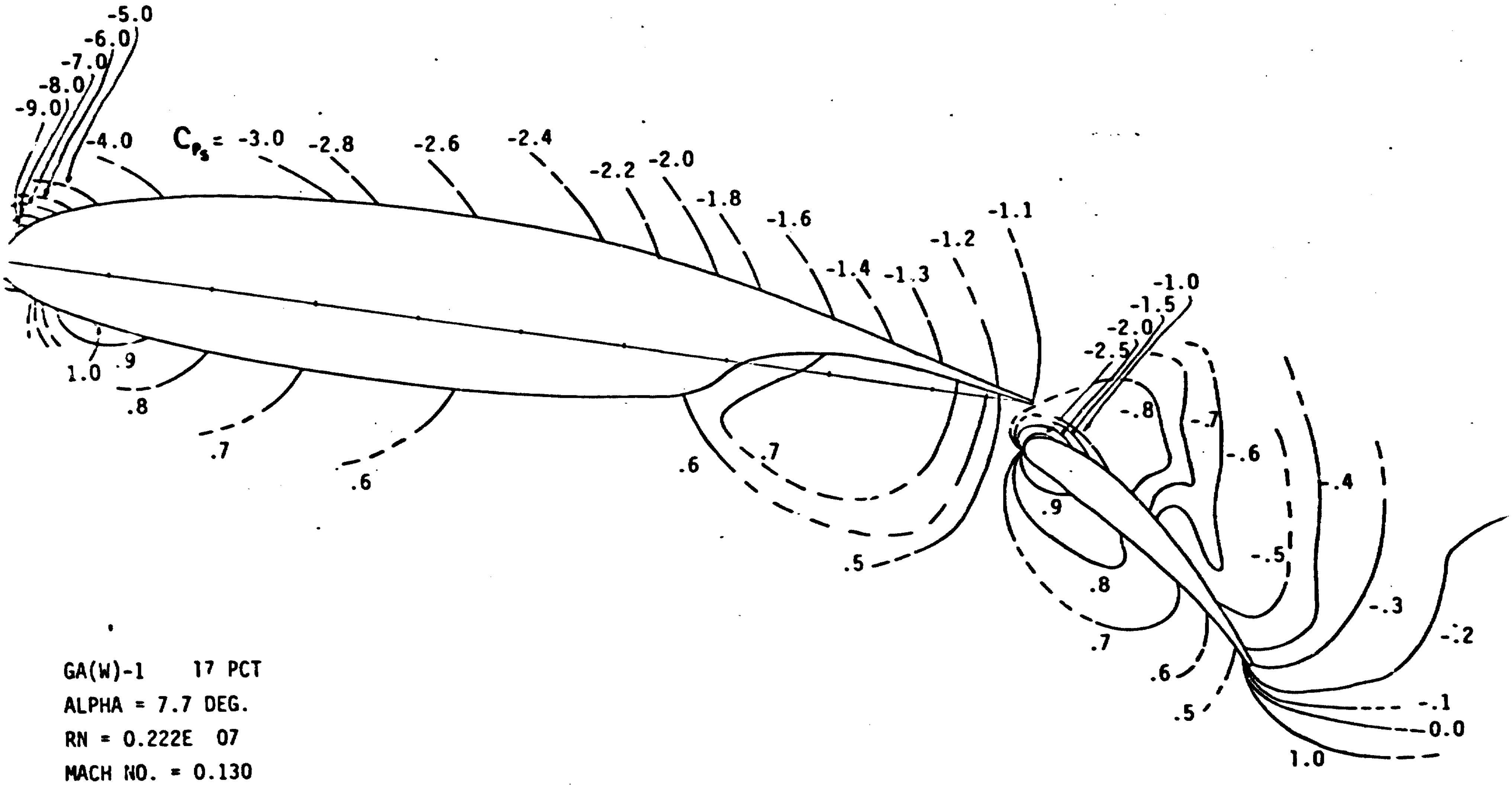
ALPHA = 2.7 DEG.

RN = 0.222E 07

MACH NO. = 0.130

FLAP 40°

Figure 12



GA(W)-1 17 PCT
ALPHA = 7.7 DEG.
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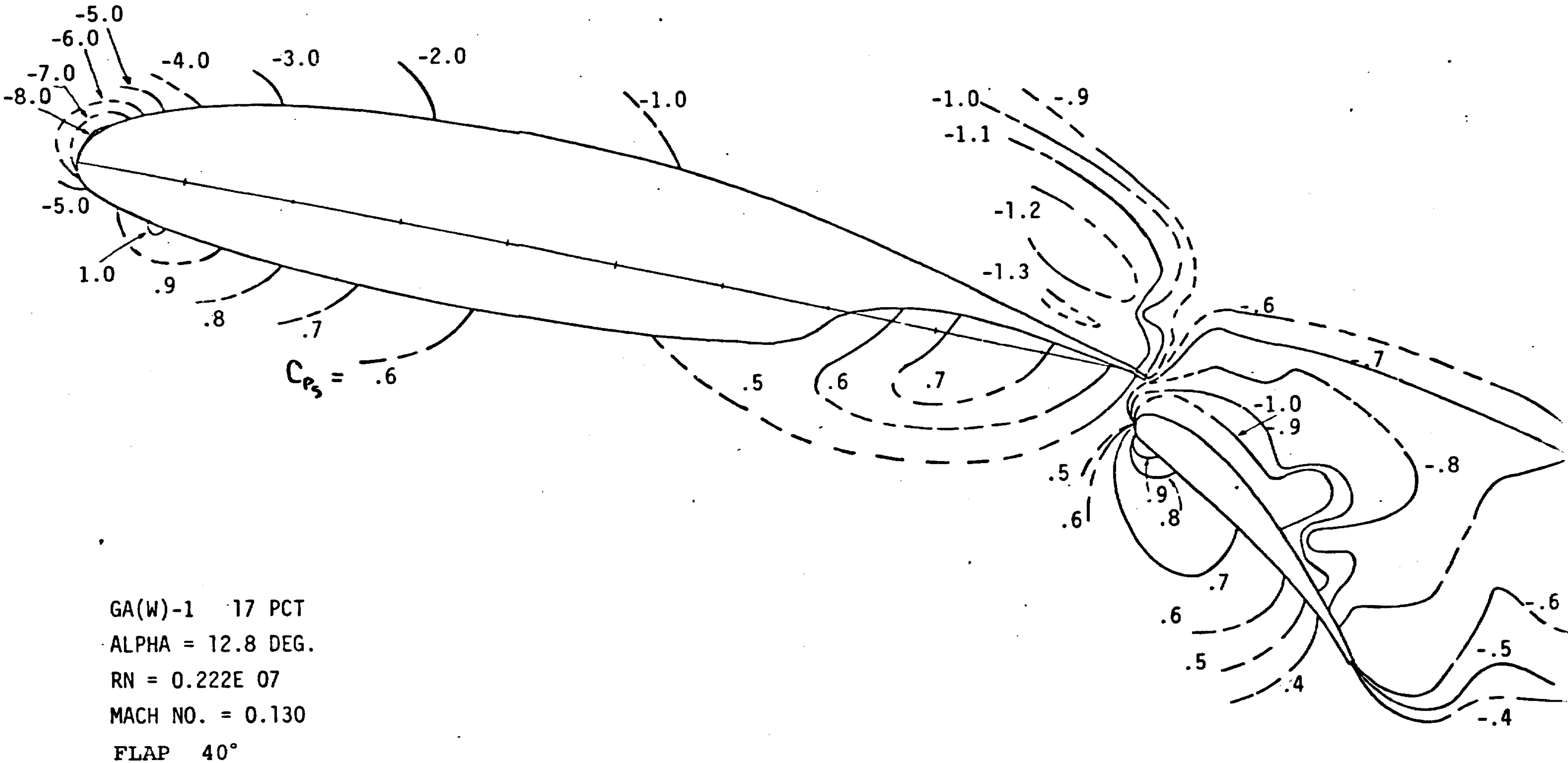
FLAP 40°

Figure 13



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GA(W)-1 17 PCT
ALPHA = 12.8 DEG.
RN = 0.222E 07
MACH NO. = 0.130
FLAP 40°

Figure 14